

computer industry, but observing that "[w]e are amazed that some computer industry proponents, who have no stake whatsoever in the broadcasting industry, would presume to limit the flexibility of the ATSC standard and dictate technologies to be used by broadcasters." Thomson (at 11-12), Zenith (at 10-11), and ATSC (at 19-20) note the emphasis of the standard on progressive scanning and stress the great amounts of material that will be transmitted using progressive scan formats, including all material originated in film (all movies and about 80% of prime time programming). Thomson (at 10), Zenith (at 10) and ATSC (at 23) reinforce our own view that any delay in adopting the standard out of interoperability concerns will only serve to entrench interlaced scanning in the U.S. and throughout the world. Expressing some bewilderment with those who still claim the standard lacks interoperability in spite of all of these features, Thomson (at 11), Zenith (at 11), and Sony (at 24) suggest that some in the computer industry are simply trying to derail the Commission's standard setting process for anticompetitive purposes.

Tektronix (at 5) notes that it has strongly advocated the adoption of progressive scan formats, but does not oppose the inclusion of interlaced scanning, saying it's not practical to demand that all video displays resolve fine text and graphics when viewed from short distances. "There are some who advocate a system whose parameters are chosen solely to facilitate operation with computers, and suggest that any concession to interoperability with existing television systems is inappropriate. Tektronix believes that such an approach is not in line with the Commission's intent, nor is it in the public interest."

MCEA (at i, 2) says proposals to excise interlaced scanning lack merit and would impede ATV. MECA (at 5) says it's an issue of idealism vs. pragmatism, there is great genius in the proposed solution, and the Commission shouldn't tamper with it. MECA (at 8-9) adds that all-progressive HDTV production is the goal and they are investing resources to achieve it, and that the continuing debate on the comparative advantages of interlaced and progressive scanning is pertinent only to HDTV production. Hitachi America (at 4) notes the

emphasis of the proposed standard on progressive scanning, saying that interlaced is included as a practical means of optimizing delivered image quality.

Sony (at 2, 14-25) offers an extensive and convincing discussion, saying that interlaced scanning deserves whole-hearted support and simply must be preserved as a critical component of our flexible new standard, that the inclusion of interlaced is essential to the timely marketplace acceptance of HDTV, and that only the inclusion of interlaced and progressive scanning will permit the immediate broadcast of both film and live events TV in full high-resolution HDTV.

ATSC (at 22) defends the inclusion of interlaced formats, saying they are useful for transmitting archived interlaced material and for interoperability with current high-definition production equipment and the installed base of NTSC production and studio equipment, and that for video not originally produced on film, more SDTV programs can generally be offered simultaneously using interlaced scan.

Many parties, including the Broadcasters (at 10), MECA (at 9), MPAA (at 6), Sony (at 27), and ATSC (at 20, 26, fn. 17), point out the ability in a digital system to separate production, transmission and display capabilities in a total system, in some cases criticizing the opponents of interlaced scanning for confusing transmission formats with display or production formats. Sony (at 23), ATSC (at 21) and MECA (at 9) argue that de-interlacers work well and are affordable.<sup>36</sup> ATTC (at 7) states that with the cooperation of several manufacturers it "has demonstrated to the Commission that consumer-level technology is now available for products that will enable consumer receivers to display selectively a wide range of field rates, aspect ratios, type of scanning , and even colorimetry characteristics

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<sup>36</sup>Sony has demonstrated to the Commission a commercially available HDTV home receiver that accepts a 60 Hz interlaced scanned input television signal and displays it at full 60 frame progressive. "We emphasize that such de-interlacing is today a well-known art -- cost effective, implementable in VLSI, already available in some receivers, and finally, as the Commissioners recently witnessed, it works very well." (Sony Comments at 23) Similarly, Carroll (at 3) says de-interlacing is no longer a big deal, because converters can output progressive or interlaced regardless of how the signal is received, since the hardware (memory) cost of storing a frame is trivial.

independent from the parameters chosen for production or transmission. Such technology makes it both feasible and affordable at the consumer level to combine computer scanning and any of the broadcast video scanning standards on any chosen display, regardless of its native characteristics . . . "<sup>37</sup>

Notwithstanding all of these compelling reasons for including both progressive and interlaced scanning formats in the standard, a number of parties continue to oppose any inclusion of interlaced scan in the transmission standard. They raise a wide variety of complaints, ranging from wild assertions that amount to little more than name calling, to highly technical claims about compression and coding efficiencies, backed up by "supporting" papers that often contain data that calls into question their conclusions or that don't support the referenced conclusion at all. We do not attempt to address every error or misconception expressed in the comments, nor every opinion that differs from ours, but we do address enough here to demonstrate the folly of any attempt by the Commission to adjudicate every claim and counterclaim in what is practically a religious debate. That's why the Commission established an Advisory Committee, and the Advisory Committee did a superb job forging a consensus. That several vocal detractors remain *in industries not directly involved in the provision of free over-the-air television* should not deter the Commission from bringing a successful conclusion to this historic effort.

One of the most responsible comments, although we disagree with it, is made by ITI (at 2). Although they support the rapid adoption of a DTV standard, they state that the Commission can minimize the cost of DTV investment by going directly to progressive scanning, and that including interlaced scanning will perpetuate an inferior technology and delay the convergence of technologies. As described in our initial comments, we believe that including some interlaced formats in the predominantly progressive scan standard offers

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<sup>37</sup>See Letter of Lawrence Petak to the Acting Secretary of the Commission re an oral *ex parte* presentation by IBM and Snell & Wilcox describing their *Multi-Media Bridge*, a device capable of processing any current broadcast standard as input and displaying any desired picture standard as output.

important benefits to broadcasters. And as explained more fully below in our responses to other complaints about the standard, we believe concerns that incorporating some interlaced scanning formats in the standard will delay the convergence of technologies are completely overblown.

In one of the least responsible comments, McKnight and Bailey (at 1) state that failure to eliminate the costly and unnecessary interlaced formats will cost consumers billions of dollars, and may in fact doom the whole enterprise to failure, saying Japan introduced an interlaced HDTV system which failed in the marketplace; Europe introduced an interlaced HDTV system which failed in the marketplace; and there is no reason to believe that the Grand Alliance standard will not meet a similar fate unless interlace is eliminated. McKnight further adds that the Commission will accelerate the abandonment of broadcast TV by including interlaced scanning.

Logic such as this could easily prove that pigs can fly! No informed observer of digital television developments believes that the presence of interlaced scanning is the cause of slow growth of analog HDTV. For example, the lack of programming is clearly the most significant factor in the slow growth of HDTV in Japan, where years after introduction of the service, there is still only one (satellite) channel available. And apart from the obvious hyperbole in these statements, they seem to take no account of the rapid adoption in the U.S. and elsewhere of digital television systems that use interlaced scanning *exclusively*. Indeed, as we continue this endless debate, interlaced scanning is becoming entrenched here and around the world. Furthermore, it seems unlikely to us that McKnight and Bailey know more about what is needed to help preserve broadcast television than the collective voice of the entire terrestrial broadcast community that is united in its support for the proposed standard.

Other "experts" on this issue believe interlaced scanning must be banned for just the opposite reason. Compaq (at 16) says "[c]ommentators have cautioned that the inclusion of interlaced scanning will doom progressive scanning to extinction, despite the technical and economic advantages of progressive scanning. Compaq attributes this opinion to Delogne,

but Delogne's paper does not make this assertion at all, but in fact compares the U.S. situation *favorably* to that in Europe *because* of the inclusion of progressive scan formats here.

CICATS (at 12-13, A-5) makes an argument similar to Compaq's assertion.. Both parties also reference a similar statement made by William Schreiber in March, 1996, but his more moderate statement in these comments (Vol. I at 2, 4) is that the presence of interlaced scanning formats will inhibit the migration to progressive scan, although he does mention his earlier statement regarding "the danger that progressive scan will never be used if interlaced transmission is permitted." Schreiber also argues that including interlaced scan will eliminate the possibility for the system to be improved over time in a manner that does not make unusable much of the equipment first deployed, especially receivers in the hands of the public. And Demos (at 1-2) urges the Commission to forbid interlaced transmission formats, or else they'll get the Japanese interlaced standard for HDTV and the NTSC format for SDTV.

None of these allegations bears scrutiny. That they are repeated frequently, but not supported, does not make them true. In the first place, as we've explained, there will be a tremendous amount of progressive scan transmission from the first day, if for no other reason than the fact that all film-originated material (all movies and 80% of prime time programming, including most commercials) will be transmitted in progressive scan. And we expect a great many video programs to be transmitted in progressive scan also. So any claim that interlace will cause the extinction of progressive is absurd on its face. We believe the industry will migrate toward more and more progressive scan transmission over time, but if we're wrong, and interlace transmission thrives, then presumably it would reflect real needs being met in the marketplace. And Schreiber's claim that including interlaced scanning will eliminate the possibility for the system to be improved over time without rendering first generation equipment useless is demonstrably false. We and many others have described in detail the unmatched extensibility given to the system through the use of packet headers and descriptors. This capability exists independently of any particular scanning format.

Microsoft (at 6) says that interlaced scanning and non-square pixels make the standard incompatible with computers. Microsoft (Mundie attachment at 7), along with Compaq (at 17) and CICATS (at 23), also claims that even if one computer unfriendly format is included, receiving equipment will need to perform additional conversions and decoding to enable interaction with computer applications. CICATS (at A-4) boldly estimates the aggregate cost to this conversion to consumers, assuming \$400 (!) for the cost of a quality de-interlacer, times 214 million receivers equals \$85.6 billion!

First, an absolute statement that including interlaced scanning formats makes the standard *incompatible* with computers is demonstrably wrong on its face. Combination PC/TV products exist in the market today using analog NTSC technology. Interoperability with computers would be tremendously enhanced compared to these offerings even if the standard supported interlaced transmission formats exclusively, which of course it doesn't.

Second, for the next ten to fifteen years or so, every television using a progressive scan display will need to incorporate a de-interlacer in any event if for no other reason than to receive and display NTSC transmissions during the simulcast period. Thus, at least one so-called "computer unfriendly" format is guaranteed.

Third, CICATS' estimated cost of a high-quality de-interlacer is wildly inflated. As shown in Appendix A to these comments, we believe that the incremental parts cost of a high-quality de-interlacer in 1996 is \$28 to support a high-end receiver with a high-resolution 720-line progressive scan display, and \$2 to support a mid-line receiver with a 480-line progressive scan display. Applying Moore's Law to reflect anticipated improvements in integrated circuit technology price/performance means the high-end receiver figure will be totally negligible by 2004 when substantial market penetration is occurring. Thus, these

parties' claims that expensive conversions required by the presence of any interlaced scanning format will render the standard incompatible with computers are completely overblown.<sup>38</sup>

Finally, although little more needs to be said, CICATS' estimate assumes that *every* TV in America will utilize a progressive scan display and therefore need a de-interlacer. We believe that a great many receivers with progressive scan displays will be sold for a variety of reasons, but that it's likely that there will also be a market for less costly models using interlaced displays, and thus not requiring a de-interlacer.

CICATS (at 25, 27) further claims that off-shore manufacturers were primarily responsible for the decision to include interlaced scanning, and that including interlaced scanning will raise costs, making it harder for computer companies to compete against incumbent receiver manufacturers for whom the standard was tailored.

Once again, it is the Advisory Committee, and especially broadcasters, who defined the requirements for the ATSC DTV Standard, and the Advisory Committee recommendation reflects a strong and broad consensus among the parties directly involved in the provision of free over-the-air television, achieved only after years of debate on these very issues and others. Furthermore, we believe that the processing required to make these conversions will be incorporated in widely available integrated circuits at competitive prices from a variety of sources. These claims that the proposed standard puts computer companies at an unfair competitive disadvantage are groundless.<sup>39</sup>

William Schreiber (in his May 9, 1996 letter to the Commission), asserts that with the recent introduction of a progressive scan camera by Polaroid, "the last remaining argument for including an interlaced format in digital television has now been removed."

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<sup>38</sup>Similarly, Polaroid's claim (at 2) that de-interlacing at home is either expensive or poor quality, and RPCP's contention (at 3) that interlace requires costly and complex signal processing to make text and fine-line computer graphics acceptable though still impaired to the human eye, are greatly overstated.

<sup>39</sup>Having been misled, we believe, by detractors of the standard, CFA/MAP (at 4, 7) repeats this fallacy, saying that the inclusion of interlaced scanning effectively insulates incumbent TV receiver manufacturers from new competition. However, they also find it inconceivable that a solution cannot be found to convert interlaced to progressive and vice versa. Indeed, as shown above, they are absolutely right. Cost-effective means to perform these conversions are already in hand.

Polaroid (at 2) and RPCP (at 4) make the same claim, while CICATS (at A-4) argues that this development negates the Grand Alliance's claim that an interlaced format is necessary for high-quality HDTV.<sup>40</sup>

While the development of this camera is a welcome technical achievement that will help facilitate even greater use of the progressive scan formats in the ATSC DTV standard, it in no way removes the fundamental tradeoffs between progressive and interlaced scanning that make each of them advantageous and desirable for certain applications and under certain conditions. For example, the existence of a progressive camera does not mean that such a camera exhibits the same level of low-light sensitivity as an interlaced camera, a performance aspect that is vitally important for Electronic News Gathering (ENG) use. Likewise, no camera development can influence the compression related impact of interlaced scanning, which presents the compression encoder with one-half the number of pixels to compress compared to a progressive scan format of the same temporal rate and the same number of vertical lines. While interlacing causes the well-known interline flicker artifact, it must also be considered that compressing twice as many pixels in a progressive scan format would result in other compression artifacts, typically increased blockiness and noise in the picture. It is by no means established that either of these data reduction approaches (i.e., interlacing or greater data compression) is consistently preferable to the other. In fact, ATTC test results from the first round of testing clearly show that each approach offers advantages with different types of picture material. For such reasons, the Grand Alliance decided upon the inclusion of both formats, so that each content producer and broadcaster (collectively, the marketplace) could select their preferred format.

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<sup>40</sup>CICATS (at A-4) also states that Polaroid has introduced the world's first progressively scanned HDTV camera, the performance of which has been judged "superior to the 1080-line interlaced HDTV format in the [Advisory Committee] standard." This camera, developed by Polaroid, Philips/BTS, and MIT, though *not* the first progressive scan camera, offers performance characteristics that are greatly improved over earlier designs. CICATS' comparison of the camera to a transmission format is confusing, but assuming they mean interlaced cameras that output that format, their comparison is not based on independent, objective testing, but on the opinions of the justifiably proud developers of the new product. The marketplace will determine exactly how good this new product is for various applications.

Moreover, Schreiber totally ignores the fact that the interlaced and progressive formats do *not* have the same horizontal resolution. He states "However, in the case of ATV, we are talking about coded digital systems, in which the data rate for the P and I formats are the same. In that case, the 720-line P format will have the same resolution as the 1080-line I format, as well as freedom from all interlace artifacts." Recalling that the DTV formats he is referring to are 1280 x 720 and 1920 x 1080, even if we were to agree with Schreiber that the vertical resolution is identical (and we're not convinced it is), his statements do not account for the increased horizontal resolution and resulting increase in picture quality that is provided by 1920 horizontal pixels compared to 1280.

Schreiber also claims (Vol. I at 11) that progressive scan doesn't require more channel capacity, because higher correlation permits a *doubling* of the compression ratio so that the same coded data rate is required for either scanning technique.<sup>41</sup> The references he attaches are not convincing, either because they proffer no such conclusion or because their results suggest different conclusions than they draw. In this case, we seem to have an existence proof that casts great doubt on his assertion. The Grand Alliance developers used every means possible within the MPEG-2 compression standard to get the best picture quality possible, and the 1080-interlaced format, presenting the encoder with 93.3 Mpixels/second ( $1920 \times 1080 \times 30 \times 1.5$  (a factor to reflect both luminance and chroma information)), and the 720-progressive format, presenting the encoder with 83.0 Mpixels/second ( $720 \times 1280 \times 60 \times 1.5$ ), delivered approximately equal quality, at least as judged by non-expert viewers subject to the quality limitations of the particular receivers utilized. At the maximum 19.3 Mbps payload of the transmission channel used for both formats, this means the encoder required .21 bits per pixel for the interlaced format, and .23 bits per pixel for the progressive format, i.e., the coding efficiency for progressive was about the same, or a bit less, but certainly not

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<sup>41</sup>Specifically, Schreiber (Vol. II, cover letter) claims that "[a] progressive-scan signal having the same frame rate as an interlaced signal, and the same number of lines/frame, and therefore having twice the analog bandwidth, when coded by MPEG, uses exactly the same data rate for compression."

double that for interlaced. Indeed, if Schreiber's claim were true, we could transmit a 1080-line, 60 Hz, progressive scan format today within a 6 MHz terrestrial channel, and this tiresome debate would be over, at least for high-definition television. But we cannot, as he himself admits.<sup>42</sup>

In addition to Schreiber, CICATS also submits a variety of technical papers in support of their claim that interlaced scanning is not necessary. However, these papers either contain careful disclaimers by the authors about particular conditions under which their experiments were conducted, or have mixed results subject to a variety of interpretations, or actually demonstrate an advantage for interlaced scanning. For example, Guillotel and Pigeon, in examining the influence of bit rate on compressed progressive and interlaced material, indicate a consistent picture quality advantage for interlaced scanning that increases at low bit rates.<sup>43</sup> Stated another way, this means that interlaced scanning can provide the same picture quality as progressive scanning, but at a lower bit rate. This performance advantage is important, because, e.g., it might enable an additional SDTV program or additional information services to be fit into the broadcast channel, allowing broadcasters to

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<sup>42</sup>See Reply Comments of William Schreiber, August 6, 1996, at 5. (Such capacity could be achieved, but only for "downtown" viewers, by using a multiresolution "layered" system in which receivers recover a variable amount of data depending on the signal quality.)

<sup>43</sup>P. Guillotel and S. Pigeon, "Progressive versus Interlaced Coding," Appendix to Comments of CICATS. The following data is taken from Table 5 where Guillotel and Pigeon compare the performance of interlaced scan and progressive scan for a Standard Definition format. (A higher peak signal-to-noise ratio ("PSNR") indicates better picture quality, and most experts agree that a 0.5 dB improvement in PSNR is readily noticeable.)

PSNR at Different Bit rates

	Progressive	Interlace	Interlace Advantage
6 Mbits/sec	37.98 dB	38.58 dB	0.60 dB
4 Mbits/sec	36.35 dB	36.99 dB	0.64 dB
2 Mbits/sec	32.17 dB	33.87 dB	1.70 dB

Guillotel and Pigeon clearly state their conclusion: "Table 5 clearly shows that if interlace is better at high bit rates, this is still true at low ones if not even more (from 0.6 db at 6 Mbps up to 1.7 db at 2 Mbps). The number of pels . . . are very critical at low bit rates . . . consequently, the performances of the progressive format decrease faster than those of the interlaced one at low bit rates." This clearly supports the usefulness of interlaced formats for carrying multiple programs, which necessitates low bit rates.

provide local news and information simultaneously with an HDTV movie, or perhaps an additional educational program during after-school hours.

These results contradict the claims of Schreiber and CICATS and demonstrate that it would not be in the public interest for the Commission to ban interlaced formats from the DTV standard.<sup>44</sup>

These debates about coding efficiencies, various coding artifacts and means to avoid them, measurable delivered resolution, and a host of other factors, have been going on for years and are likely to continue. The genius of the Grand Alliance system and the ATSC DTV Standard, is that it is inclusive. No broadcaster is obligated to use any particular format, (although he or she might be foolish not to, as in the case of transmitting film-originated material in the 24 Hz progressive scan format). Rather, broadcasters will use the formats that best meet their needs. It is the marketplace, through competition and innovation, that will decide which formats are used for what purposes, and the Commission should not interfere with this process by banning interlaced transmission formats.

Several detractors of the standard, intentionally or unintentionally, continue to confuse transmission formats and display formats, e.g., SBA (at 6) says "[a]pproval of a *display* standard that permits use of interlaced technology would result in lower quality text and graphics making the product less useful and less appealing to consumers," and Microsoft (at 7, 8) says the FCC should be concerned about the quality of text and graphics *displayed* . . . , the Advisory Committee proposed standard also includes a 60 Hz *display* rate, and urges the FCC to adopt a 72 Hz *display* rate. Siggraph (Attachment) urges the Commission to mandate progressive-only *displays*, saying that to allow the interlace option is tantamount to eliminating the other options for our lifetime, since a cheaper, non-compatible standard is embraced and produced first. Demos (at 2) says the Advisory Committee standard is clearly

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<sup>44</sup>In fact, although they indicate that some day technological progress will tip the balance and make it worthwhile to move to progressive scanning, Guillotel and Pigeon conclude (at 6) that "both interlaced and progressive formats have their respective advantages and drawbacks. Choosing one of them as the definitive solution of the scanning problem would be utopian, at least when considering today's state of technology."

biased toward display of all formats on 60 Hz interlaced displays, and that the Commission should forbid the use of interlaced display in all new digital television receivers.

As we have explained before, the inclusion of interlaced *transmission* formats does not preclude the use of progressive scan *displays* where deemed desirable. Receiver and converter de-interlacers that offer excellent performance at reasonable cost already exist in the marketplace and others are expected very soon. Siggraph is clearly mistaken that the existence of interlaced displays will eliminate the availability of progressive displays, since progressive displays emerged for computer applications based on their merits, despite the complete dominance of interlaced displays in the early 1980s. Experience in both the computer and television industries prove otherwise, and numerous television manufacturers have already announced their intention to offer progressive scan displays in their initial HDTV offerings. We strongly urge the Commission to reject the proposals of Siggraph and Demos to ban the use of interlaced displays in DTV receivers.<sup>45</sup> Such an action would deprive manufacturers and retailers of the ability to market a broad range of useful products and would eliminate valuable options for consumers. Limiting manufacturer and consumer options would also extend the transition to digital television and delay the return of valuable spectrum.

For all of these reasons, the Commission should not attempt to relitigate the complex debate surrounding progressive versus interlaced scanning, but should adopt the inclusive consensus approach to incorporate both progressive and interlaced formats, as developed over the course of several years in thorough deliberations on these issues within the Advisory Committee. The Commission should adopt the ATSC DTV Standard in its entirety, including the four interlaced scan transmission formats, and should summarily reject proposals to require all DTV receivers to incorporate progressive scan displays.

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<sup>45</sup>Indeed, the computer companies whom Demos represents have long opposed government regulation of the performance or features of displays.

### **C. Square Pixels**

As part of their attacks on the proposed standard, several parties strongly object to the inclusion of non-square pixels in some of the SDTV formats.

Microsoft (at 7) says that the use of non-square pixels in two of the formats is a problem that contributes toward making the Advisory Committee standard incompatible with computers. Compaq (at 17) says that requiring both pixel formats will increase the complexity and costs of consumer equipment. CICATS (at A-6) claims that converting non-square pixel material adds costs and degrades picture quality, and that this may be good news for set manufacturers, but is bad news for consumers and those who want demand for convergent products to take off. CICATS (at A-8) says it will be much less expensive in the aggregate for broadcasters to make the conversion, and that equipment manufacturers' existing production standards may well have influenced the decision to include this enormously suboptimal feature in order to preserve the value of existing investments. RCPC (at 4) urges that all images be transmitted as square rasters, with any necessary production conversions taking place at the transmitting end, to be perfectly compatible with future display technologies such as light valve projectors and flat screens.

But as MECA explains (at 8-9), a non-square pixel SDTV format was necessary to provide backward compatibility, e.g., to enable the production of a montage digital television program where the producer chooses to include clips from old, non-square pixel NTSC programs. Consequently, to eliminate non-square pixels would restrict the creative options of future program producers and the program options of future viewers. Sony (at 3, 34) points out that the ITU-R-601 4:2:2 digital 525/625 studio origination standard was adopted almost 15 years ago, and the enormous reality of digital SDTV production -- in all 525 and 625 countries -- means that the non-square pixel SDTV format, based upon ITU-R-601 and the MPEG-2 standard, is vital to an orderly U.S. transition to digital SDTV transmission and must be maintained.

Thus, once again these complaints provide a stark example of how these commenters opposing the standard want every design decision made to maximize their narrow objectives, and are completely oblivious to any impact on *television service*, or to the needs of broadcasters or any other affected industry. And even the alleged negative impacts on the narrow applications they do consider, as usual, are grossly exaggerated. No informed party in this debate believes that the inclusion of some non-square pixel formats is "enormously suboptimal," nor does it render a digital television system "incompatible" with computers.<sup>46</sup> And asserting that set manufacturers or anyone else would benefit from adding unnecessary costs to receivers is preposterous, no matter how often these critics repeat it.

Liberty Imaging (at 2) urges the Commission to add a square-pixel version of the 704 x 480 SDTV format, i.e., 848 x 480, saying that it will be very useful for defense and other government uses. In the ATSC and Advisory Committee deliberations that eventually led to the broad industry consensus of SDTV formats, careful consideration was given to a wide variety of needs, and multiple formats were included in order to support them. Many other formats, each having some useful application, were proposed and evaluated, but ultimately not included in the consensus list. Though Liberty's suggestion is well-intentioned, we believe that the needs they identify can be accommodated fully within the included formats. The ship sailed on this issue more than three years ago, and we see no valid reason to reopen the debate on SDTV formats at this late date.

For all of these reasons, the Commission should adopt the industry consensus embodied in the ATSC DTV Standard, including the SDTV formats that contain non-square pixels.

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<sup>46</sup> Although he favors square pixels, Schreiber (Vol. II at 5) says square pixels are less important to the computer industry than progressive scan, and it would not be the end of the world to permit the 480 x 704 SDTV format. non-square pixels is not as important, but that the weight of the argument is on the side of square pixels. Carroll (at 1) says that non-square pixels should be a self-liquidating temporary measure, provided only for backward compatibility at lower performance levels. This is the case. All of the HDTV formats use square pixels exclusively, but as explained above, some of the SDTV formats include non-square pixels to provide backward compatibility with existing 525/625 television standards.

#### **D. Refresh Rate**

The same collection of computer companies and film makers objects to the picture refresh rates included in the ATSC DTV Standard.

CICATS (at *iii*, A-11) claims that by not permitting broadcasters to transmit at rates above 60 Hz, the Advisory Committee standard guarantees that every DTV broadcast will have to be converted in computer-compatible displays. Compaq (at 18) says picture rates of 30 and 60 Hz can be upconverted for display on computer monitors, but it requires costly additional processing power and degrades picture quality. Microsoft (6) and BSA (at 6) make similar complaints about the need for higher rates. Demos (at 1-2) urges the Commission to reject the obsolete 29.97, 30, 59.94, and 60 Hz frame rates, and also recommends 72 Hz as a more natural *display* rate.<sup>47</sup>

One again, these complaints demonstrate a myopic focus on the narrow DTV applications of interest to these parties, showing an utter disregard for any impact on the interoperability concerns of other affected parties, and for the ability of their proposals to provide high-quality television service over 6 MHz terrestrial channels. Increasing transmission frame rates from 60 Hz to 72 Hz increases the pixel rate a video coder must handle by 20%, and this cannot be done without paying the piper somewhere else.<sup>48</sup> In the case of the highest resolution formats, this can only show up as a degradation in quality and it is a very substantial degradation indeed. And to claim that this is pure speculation, as

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<sup>47</sup>Once again, CICATS (at A-11) states that existing manufacturing standards may have influenced the Grand Alliance's selection. This is silly. In the first place, the Advisory Committee, not the Grand Alliance, recommended the standard. Beyond that, choice of a frame rate is a tradeoff between many factors, and for the primary application of broadcast television, 60 Hz is fully adequate. And as we explained in detail in our initial comments, transmission rates need not be the same as display rates, and those applications that require a higher display rate can easily make the necessary conversions. Indeed, Hitachi America (at 4) states that 60 Hz is appropriate for the transmission standard, but actual *display* rates are not limited by the standard, and Sony (at 26) explains that any refresh rate desired can be utilized in displays, noting that they have already marketed a 28", 16:9, 72 Hz, 1920 x 1080, progressive scan computer display.

<sup>48</sup>As Sony points out (at 3, 26), the 60 Hz transmission rate ensures full resolution HDTV transmission through the narrow 6 MHz channel, but the critics of the 60 Hz refresh rate appear oblivious to the fundamental linear relationship between television frame rate and the bandwidth required to sustain that frame rate.

CICATS and others do, is nonsense, when companies with experience in building digital video encoders know otherwise.

To be sure, some cost will be involved in making personal computers capable of receiving DTV broadcasts, just as it will involve added costs to make digital televisions capable of handling information services that go beyond traditional television services. But this doesn't mean that every television should be required to bear the cost of doubling as a computer monitor, nor that the quality of terrestrial broadcast television services should be sacrificed in order to make computers that handle DTV transmissions marginally less expensive.<sup>49, 50</sup>

On this issue the motion picture industry is again split. MPAA (at 7) says complaints about the 60 Hz transmission rate are unwarranted. However, the Film Makers Coalition (at 9) supports the 24 Hz refresh rate in the Advisory Committee proposal, but expresses concern regarding the 30 Hz and 60 Hz rates, fearing that broadcasters might use these rates with the 3-2 pulldown technique rather than the 24 Hz rate to transmit film. The Film Makers should be reassured that broadcasters will always transmit motion pictures in progressive scan at a 24 Hz refresh rate. The 24 Hz rate was specifically included in the standard to take advantage of the fact that film is produced in 24 Hz and can therefore be sent at that low frame rate, yet displayed at higher rates in receivers. An ATSC DTV encoder can automatically detect any material that was originally produced in film, including all movies and about 80% of all prime time television programming, and send that material using one of

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<sup>49</sup>Carroll (at 3) says accommodating the desires of computer companies for a higher refresh rate is a tougher problem, and suggests that computers fall back to 60 Hz when displaying broadcast signals simultaneously with computer output. Schreiber (Vol. I at 10) first says that the computer industry's preference for 72 or 75 Hz is much harder to satisfy, that upconversion at the receiver is possible but expensive, and that it's too late to make fundamental changes. In his second submission (Vol. II at 1), however, he mentions including any frame rate that is a multiple of 12 as an improvement that could be made to the system. For the reasons outlined above, we do not agree that changing the frame rate to include any multiple of 12 would be an improvement to the system, but we certainly agree that it's too late to make fundamental changes, particularly such ill-advised changes.

<sup>50</sup>Thus, Demos' suggestion that the Commission regulate DTV receivers to require a 72 Hz display rate should be rejected. The Commission should not regulate the performance or features of displays, as the computer industry has long held.

the 24 Hz, progressive scan formats. Broadcasters will be highly motivated to use 24 Hz progressive scan transmission for film-originated material, since it will allow them to save bandwidth which they could use to improve picture quality or to send auxiliary services.<sup>51</sup> The 60 Hz rate, of course, is the rate for video, not film, and it will be used to carry live video and recorded video material.

In our initial comments (at 24-25) we discussed this issue from a broadcaster and regulatory perspective, from a television receiver perspective, and from a computer perspective, showing conclusively that the refresh rates included in the ATSC Standard are not a problem. The other comments strongly reinforce our conviction that the Commission should adopt the ATSC DTV Standard without requiring any modifications to the transmission picture refresh rates, and that the Commission should not impose any requirements whatsoever regarding the refresh rates of displays.

#### **E. Aspect Ratio**

Some film makers and the coterie of computer industry complainers raise strong objections to the 16:9 aspect ratio incorporated in the proposed standard. Other film makers and most other parties involved in the Advisory Committee process staunchly defend 16:9.

Addressing the complaints, the Broadcasters (at 11-14) state that this flurry of dissatisfaction with the 16:9 aspect ratio comes late in the process, and reflects a disregard for the needs of the vast majority of television programming and the realities of set design. They state that 16:9 is the best choice, by far, and preferred around the world; that 2:1 would be marginally better for the widest 20% of films, but would be worse than 16:9 for the remaining 80% of films and all other 16:9 or 4:3 television programming; and that 2:1 would entail a 12.5% greater display area, which would mean 30-50% heavier TV sets, with greater weight and memory adding considerable cost to receivers.

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<sup>51</sup>The 30 Hz rate, like the 24 Hz rate, is a film mode for the DTV standard. Television commercials are often shot in 30 Hz film. As with 24 Hz film, the system will automatically detect material originally produced in 30 Hz film and send that material using a 30 Hz progressive scan format.

ATSC (at 26-27), Thomson (at 12-13), and Zenith (at 11-12) add that a worldwide industry consensus was forged long ago on the aspect ratio issue, that changing the aspect ratio at this late date would increase costs to consumers and manufacturers, and that sets with wider aspect ratios would be far more expensive. Sony (at 3, 31-32) explains that an aspect ratio must accommodate original 4:3 material, vintage motion pictures, and different widescreen formats, and still make displays affordable, and that 16:9 is an excellent choice to satisfy these multiple objectives.

Within the motion picture industry, MPAA (at 2, 4) supports the 16:9 aspect ratio, saying that it appears that a wider aspect ratio would represent a net loss to the public, both in terms of the cost of digital receivers and the overall amount of original material that can be displayed without panning and scanning or "letter boxing." Universal Studios (at 2) endorses the MPAA comments with respect to the proper aspect ratio.

In contrast, the Film Makers Coalition (at *i*, 4) urges the Commission to require that broadcasters transmit all films in their original aspect ratios, and that if receiver standards are adopted, they should include a 2:1 aspect ratio. They argue (at 3, 5) that because the Advisory Committee proposal limits broadcasters to transmitting in 1.78:1 or 1.33 :1, widescreen feature films (at 1.85:1 and wider) would be *unable* to be viewed in their original formats. They claim that for films wider than 1.78:1, broadcasters would be forced to cut down the images to fit in the more narrow aspect ratio, and that this panning and scanning technique fundamentally alters the dramatic impact of widescreen images. Thus, under the proposed standard, they claim (at 7) they must either produce images based on more narrow aspect ratios or acquiesce in the destruction of their work when displayed on DTV. As an example, they discuss how many apostles might be eliminated from Da Vinci's The Last Supper if cropping were used to accommodate poor choices of aspect ratio.

The claims that widescreen feature films would be *unable* to be viewed in their original aspect ratio, and that film makers must either use narrower aspect ratios or acquiesce in the destruction of their work, are simply wrong. Beginning with the first movie

transmitted over DTV, films can be shown in any aspect ratio desired by the movie owner by using letterboxing in the film-to-video transfer process.<sup>52</sup> With 16:9 (1.78:1) widescreen receivers (the deeply embedded worldwide standard), this would require minimal black bands (4% of the screen height) for the 80% of movies that are produced with a 1.85:1 aspect ratio, and larger black bands (25% of the screen height) for the 20% of movies produced with a 2.4:1 aspect ratio. Indeed, after making all of these complaints, the Film Makers Coalition (at 6, fn. 8) casually mentions the letterboxing solution in a footnote.

Furthermore, until someone invents a receiver that changes its physical shape on demand, the only way to show *all* films in their original aspect ratio is to use letterboxing. However, this is strictly a matter for film owners and broadcasters to work out between themselves. If a film maker insists that his or her widescreen film be shown in its original aspect ratio, he or she can insist upon letterboxing rather than panning and scanning in any agreement reached concerning DTV broadcasts of that material. There is no valid reason for the Commission to interfere in such private negotiations.<sup>53,54</sup>

Primes generally echoes the comments of the Film Makers Coalition, but further argues that 1.33:1 material is generally comparatively low resolution television, so it isn't as much of a problem to have side curtains and lower resolution on such material, and therefore, the aspect ratio should be weighted toward the wider media because wide material needs to be magnified and fill the screen and squarer NTSC material simply does not. But as the Broadcasters articulated in the comment noted above, Primes' proposal for a wider aspect

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<sup>52</sup>Schreiber (Vol. I at 10) states that a 2:1 aspect ratio is much too wide for much material that is used today, and that aspect ratios wider than 16:9 can be accommodated by the letterbox method. Carroll (at 3) says aspect ratio is not such a big issue, discussing windowing options that can be used to show video on squarish PCs.

<sup>53</sup>The Film Makers Coalition (at 7) argues that a government requirement that film images be forced into an artificial aspect ratio is inconsistent with the Telecom Act and other important principles. Of course, no one is proposing anything of the sort. Film makers can produce in any aspect ratio they desire and can insist that their work be shown in its original aspect ratio, if they wish, by using letterboxing.

<sup>54</sup>The Film Makers Coalition (at 6) also claims there is no flexibility in the standard -- present or future -- with respect to the aspect ratio. Once again, this is simply not true. Letter boxing provides complete flexibility from day one; and for the future, the ATSC DTV Standard would permit new aspect ratios to be incorporated by defining new packet identification headers in the transport system, however, such additions could not be made lightly, because of backward compatibility problems. See EIA/ATV Comments at 15.

ratio would be marginally better for the widest 20% of films, but would be worse for the remaining 80% of films and for all 16:9 HDTV and all 16:9 or 4:3 SDTV video programs. This is one more example where a complaint about the standard reflects a desire to satisfy one particular point of view without due regard for other important needs. The Advisory Committee's recommendation, by contrast, must and does provide a balanced solution to meet a wide variety of needs.

Compaq (at 18) and CICATS (at 25) argue that specifying only two aspect ratios is unnecessarily restrictive and ill-considered, and that the proposed standard is incompatible with motion pictures and will perpetuate their adulteration.<sup>55</sup> CICATS (at 26) states "Because many films have wider picture aspect ratios than the two prescribed by the ACATS standard, presentation on DTV of many films . . . would require amputation of part of the filmed image -- losing as much as 45% of the image of a widescreen movie on a 4:3 screen and resulting in viewer confusion and impairment of artistic quality. . . . Such adulteration of one of our country's most vital art forms should be avoided." (footnotes omitted)

In the first place, the ATSC DTV Standard emphasizes the widescreen 16:9 aspect ratio, and uses it exclusively for all of the HDTV formats. (One of the primary reasons for including a 4:3 aspect ratio for SDTV formats is compatibility with 4:3 computer displays!) The availability of 16:9 aspect ratio formats alleviates the problem tremendously and is a substantial improvement over today's single choice of 4:3.

Furthermore, regardless of the transmitted aspect ratio, the choice of panning and scanning or letterboxing is always available as part of the film-to-video scanning process -- and artistic control over the material is maintained uniformly for the viewing audience. It is in fact the CICATS proposal that would wreak havoc with artistic considerations. If a

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<sup>55</sup>Again, we find it remarkably inconsistent that Compaq and CICATS would vehemently criticize the proposed standard for supporting too many video formats, and at the same time criticize it for supporting too few aspect ratios.

wide variety of aspect ratios were transmitted, each television receiver manufacturer would probably handle them differently: some would letterbox, some would "auto pan-and-scan" and some would crop arbitrarily. The result of the CICATS proposal would be complete loss of artistic control by the creative community. As CICATS notes in its Technical Details exhibit (at 4), "[w]hen these constraints are removed, then any aspect ratio image can be sent through the channel. It would then be up to the receiver to display what it can by either pan-and-scan or letterboxing, or a combination of the two."<sup>56,57</sup>

Primes (at 7-8) states that deep within MPEG-2 there is a mechanism for viewers to watch panned and scanned versions of programs, and urges that this code be disabled, saying the public should not be given the choice to eliminate part of the picture.<sup>58</sup> Once again, this seems to be a request for the government to intervene *a priori* in negotiations between content owners and content deliverers. Such panned and scanned versions of programs will not exist unless the licenses granted by owners give broadcasters the right to show films in this format. This is a matter for film owners and broadcasters to resolve by themselves, but viewers should certainly not be deprived of the capability to choose if film makers agree to make choices available.

Given the great, genuine concern that film makers rightfully feel for maintaining the artistic integrity of their creations, we can't help but express again our puzzlement that some of them do not adamantly demand that any DTV standard *at least* ensure the availability of full HDTV resolution from day one of the transition to digital television. For the first time in history, HDTV offers them the ability to deliver to viewers in the home pictures with resolution comparable to that available in movie theaters. And although we are not film

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<sup>56</sup>Primes (at 7) also advocates not specifying an aspect ratio, but as explained above, we believe his recommendation would mean far *less* artistic control over the content consumers ultimately view.

<sup>57</sup>It is also notable that while espousing the need for a wider aspect ratio, CICATS own proposal is limited to a 2:1 aspect ratio at the highest resolution of its base layer format (i.e., 1024 x 512). To accommodate wider aspect ratios, CICATS must reduce the vertical resolution, which has exactly the same effect as the traditional letterboxing approach that could be performed within the context of the ATSC standard.

<sup>58</sup>Note that this MPEG provision is solely for the purpose of displaying a 16:9 picture on a 4:3 screen.

makers ourselves, we would expect that conveying the full resolution of a picture would be at least as important as maintaining its full spatial extent in terms of preserving artistic integrity. Isn't it at least as important to see a tear in Jesus' eye as to see all twelve apostles? With HDTV, film makers can show both.<sup>59</sup>

We believe that the logical extension of the Film Makers' aspect ratio arguments to picture resolution would have them ask the Commission to impose a requirement that all movies be delivered in their full original *resolution*, i.e., in HDTV. While we would not endorse such a policy, we are amazed that some of them have chosen to embrace the unproven CICATS counterproposal that does not incorporate HDTV at all in the base-line FCC standard, but only promises HDTV in future enhancement layers if market demand develops and if doubtful, untested technical claims bear fruit. These particular members of the film industry seem to be swatting at the aspect ratio gnat, while swallowing the resolution camel!

For all of these reasons, we urge the Commission to adopt the ATSC DTV Standard, including the aspect ratios recommended by the Advisory Committee.

#### **F. Need for a Data Broadcast Standard**

As noted previously, several parties, including Intel (at 3), CICATS (at 17, A-12), and Compaq (at 21), have expressed the need to ensure that the ATSC DTV Standard can deliver computer data, including executable code, but that they intend to pursue this in appropriate industry groups and this work needn't postpone action to adopt a standard. Demos (at 8) urges the Commission to refer the transport portion of the standard to a competent committee for additional work to provide error-free data delivery.

Hitachi America (at 7) highlights the flexibility provided by the ATSC DTV Standard for defining data services different than video services, and ATSC (at fn. 7) describes the effort it has begun to define a data broadcast standard, including its efforts to involve more

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<sup>59</sup>In particular, when a wide aspect ratio must be accommodated, the extra vertical resolution of full HDTV allows letterbox composition without the degradation that is apparent on 480-line systems such as NTSC.

members of the computer industry in pursuing this activity. Indeed, since the initial comments in this proceeding were filed, this ATSC working group, chaired by Intel, has held its first meeting.<sup>60</sup>

#### **G. Interoperability with Other Delivery Media**

In our initial comments we noted the significant investments and contributions of the cable industry throughout the Advisory Committee process to ensure the suitability of the standard for carriage over cable systems, saying that as a result we believe that as voluntary standards activities continue in the cable industry, and for other video delivery systems, it is likely that many elements of the terrestrial ATV standard will also be incorporated in emerging standards in these industries. We further stated our belief that such voluntary standards will promote the early availability of digital television, including HDTV, over all of these other media as well as terrestrial broadcasts, without causing undue burdens on cable operators or other providers, and that the ability of these other competitive delivery media to introduce compelling new technologies without FCC review and approval will continue to provide pressure to ensure that universal broadcast television service implements the technology required to remain responsive to consumer needs.

The Broadcasters (at *iii*, 2, 24-32) take a different view, urging the Commission to take all steps necessary to ensure that the cable industry adopts the ATSC DTV Standard, or achieves maximum commonality with it, saying that in addition to adopting the terrestrial broadcast standard, other measures may be necessary to bolster consumer confidence that the sets they buy will be compatible with cable and other video transmission technologies. The Broadcasters describe in some detail the benefits they see flowing from intermedia compatibility forged by a common standard. They prefer a regulatory alternative whereby the Commission would require cable systems and other video distribution systems to adopt the DTV standard, but say that the next best, but far less preferable, alternative would be to

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<sup>60</sup>This work is likely to result in an industry standard that is supplemental to the ATSC DTV Standard. As with other supplemental standards, it need not be incorporated into the Commission's rules.

require intermediate levels of commonality. They advocate specific requirements for various scenarios that will occur during and after the transition to DTV, and urge the Commission to adopt firm principles in this proceeding, but work out the details in a separate proceeding, so that expeditious licensing of DTV channels is not further delayed.

ABSOC (at 3) notes the importance that standards adopted for ATV and for other delivery media, including cable, satellite, and telecommunications networks, include a maximum degree of commonality, to ensure both interoperability and acceptable levels of cost to consumers and service providers. Similarly, Schreiber (Vol. II at 3) says the standard should discourage the proliferation of noncompliant receivers for cable, DBS and niche markets. Receivers for any new TV service should be usable for all new TV services.

In contrast to the Broadcasters, most manufacturers favor relying on market forces, but note the benefits of rapid adoption of the ATSC terrestrial broadcast standard for encouraging compatibility with other delivery media. For example, MECA (at 10-11) states that market forces will provide an incentive to non-broadcast industries to support the ATV Standard if it is promptly adopted, and urges the Commission to act rapidly before proprietary technologies become entrenched, while Dolby (at 4) argues that a strong FCC mandate for the ATSC DTV Standard would promote interoperability with other media.

ATSC (at *iii*, 27), Thomson (at 14), and MPAA (at 8) echo the view that as voluntary standards efforts continue for other video delivery media, it is likely that many elements of the terrestrial ATV standard will be incorporated in emerging standards in these industries. Zenith (at 13) and Thomson (at 14) state that the ATSC DTV Standard should provide the core of these other standards. General Instrument (at 8) notes that the ATSC standard is highly interoperable with non-broadcast transmission media without limiting the flexibility of those media. While 8 VSB modulation was selected for broadcast television, satellite systems employing the same digital audio and video compression will use QPSK, while cable TV is deploying 64 QAM and eventually 256 QAM. In this way, manufacturers can take

advantage of maximum commonality of components without sacrificing the special benefits of different transmission media.

Zenith (at 13) states "[i]n light of the fact that approximately 60 percent of all television viewing in cable TV homes is of broadcast television stations, it is vital that the Commission assure that cable transmission and other video delivery methods are compatible with the broadcast DTV standard, i.e., that cable signals are compatible with ATSC-compliant receivers, based on known standards. Ultimately, receivers and converters that perform both VSB and QAM demodulation may be feasible, but the cable industry needs to agree upon a single QAM approach.

EIA/ATV (at 16-17) argues persuasively that the rapid implementation of the broadcast ATV standard will create momentum that should facilitate the resolution of many technical issues without Commission intervention, and that DTV implementation should not be delayed pending resolution of all of the nettlesome cable interoperability issues. Once the ATSC DTV Standard is adopted and several additional minor steps have been taken, EIA/ATV believes that marketplace forces and the voluntary standards-setting process will foster resolution of the remaining issues.

The cable industry commenters oppose applying the standard to cable or other video delivery media. NCTA (at 12, Owen appendix at ¶38) argues strongly that the Commission need not become involved in assuring compatibility between digital broadcast standards and digital standards for cable and other delivery media. While the standard may *work* on cable and other media, there is no reason to believe it is optimal for the public, the vast majority of whom receive video by means other than terrestrial broadcast.

TCI (at 3) states that imposition of the ATSC standard would be especially ill-advised for non-broadcast multi-channel video program distributors (MVPDs), and that TCI and other MVPDs have invested billions of dollars in state-of-the-art digital technologies that would be undermined by a government-imposed digital broadcast standard. TCI (at 20) notes that even if different transmission standards are employed by broadcasters and cable, if all new digital